

AMENDMENTS TO THE CLAIMS

1. (Currently Amended): A wheel rotation detecting device, comprising:
a rolling bearing unit including:
a stationary ring supported on a suspension and being unrotatable in use;
a rotary ring supporting a wheel thereon and being rotatable with said wheel; and
a plurality of rolling elements respectively rollably interposed between a stationary side raceway formed in a peripheral surface of said stationary ring and a rotary side raceway formed in a peripheral surface of said rotary ring;
an encoder supported on said rotary ring or on a part mounted on said rotary ring and being rotatable with said rotary ring;
a first sensor supported on said stationary ring or a part mounted on said stationary ring in such a manner as to be opposed to said encoder, for detecting the rotation of said rotary ring; and
at least one second sensor disposed within a holder holding said first sensor, for detecting the condition of said rolling bearing unit;
wherein said holder is retained within a case of non-magnetic metal holding said first and second sensors and is made of synthetic resin,
wherein said second sensor outputs a signal used to detect when an abnormality is present in said rolling bearing unit or a portion adjoining said rolling bearing unit, and
wherein said wheel rotation detecting device further comprises:
a threshold value setting circuit that sets a threshold value in accordance with the rotation speed of said rotary ring detected by said rotation detecting sensor so as to increase said threshold value as said detected rotation speed increases;
a comparator for comparing said threshold value with the detect signal of said second sensor; and
an abnormality judge circuit for judging the presence or absence of said abnormality in accordance with an output of said comparator.

2. (original): The wheel rotation detecting device as set forth in claim 1, wherein said second sensor includes a temperature sensor for detecting the temperature of said rolling bearing unit.

3. (original): The wheel rotation detecting device as set forth in claim 1, wherein said second sensor includes a vibration sensor for detecting the vibration of said rolling bearing unit.

4. (original): The wheel rotation detecting device as set forth in claim 1, wherein said second sensor includes a temperature sensor for detecting the temperature of said rolling bearing unit and a vibration sensor for detecting the vibration of said rolling bearing unit.

5-6. (canceled).

7. (original): The wheel rotation detecting device as set forth in claim 2, wherein said temperature sensor is disposed on a leading end of said holder in such a manner as to be situated near to and opposed to a peripheral surface of said rotary ring.

8. (previously presented): The wheel rotation detecting device as set forth in claim 1, wherein said second sensor includes a vibration sensor and said vibration sensor is disposed in series with said first sensor in an axial direction of said holder, and nearer to a base end side of said holder than said first sensor in the axial direction of said holder.

9. (previously presented): The wheel rotation detecting device as set forth in claim 3, wherein said vibration sensor is one that detects vibrations at least in two directions.

10. (previously presented): The wheel rotation detecting device as set forth in claim 29, wherein the vibration sensor comprises two components, each component detecting vibrations in one of the two directions.

11. (previously presented): The wheel rotation detecting device as set forth in claim 29, wherein the vibration sensor is one that detects vibrations in three directions.

12. (original): The wheel rotation detecting device as set forth in claim 1, wherein said encoder is magnetized along a circumferential direction thereof and said encoder includes S and N poles disposed on a peripheral surface thereof such that said S and N poles are alternately situated at regular intervals along the circumferential direction thereof.

13. (original): The wheel rotation detecting device as set forth in claim 1, wherein said encoder is magnetized along a circumferential direction thereof and said encoder includes S and N poles and non-magnetized areas disposed on a peripheral surface thereof so as to repeat one another at regular intervals along the circumferential direction thereof.

14. (previously presented): The wheel rotation detecting device as set forth in claim 12, wherein said first sensor includes a magnetic detection element and a waveform shaping circuit and does not include a permanent magnet.

15. (canceled).

16. (previously presented): The wheel rotation detecting device as set forth in claim 37, wherein said second sensor includes a temperature sensor for detecting the temperature of said rolling bearing unit.

17. (previously presented): The wheel rotation detecting device as set forth in claim 37, wherein said second sensor includes a vibration sensor for detecting the vibration of said rolling bearing unit.

18. (original): The wheel rotation detecting device as set forth in claim 3, further comprising:

a period analysis circuit for analyzing the period of the vibration detected by said vibration sensor, and outputting a signal representing said period; and

an abnormality determination circuit for judging the presence or absence of said abnormality in accordance with said signal representing said period and a signal representing the rotation speed of said rotary ring detected by said first sensor.

19. (previously presented): The wheel rotation detecting device as set forth in claim 33, wherein the abnormality is that flaking has occurred in a portion of the rolling bearing unit, and said abnormality detecting circuit detects where the flaking has occurred based on the signal representing the period.

20. (previously presented): The wheel rotation detecting device as set forth in claim 17, further comprising:

a variable filter passing a signal detected by said vibration sensor, wherein the variable filter varies a removing frequency or a damping frequency in accordance with the rotation speed.

21. (previously presented): The wheel rotation detecting device as set forth in claim 3, further comprising:

an envelope processing circuit for processing a vibration signal output from said second sensor;

a frequency analysis circuit, for receiving the processed vibration signal, for analyzing said processed vibration signal, and for outputting a signal representing a period of the processed vibration signal; and

an abnormality determination circuit for judging the presence or absence of said abnormality in accordance with said signal representing said period and a signal representing the rotation speed of said rotary ring detected by said first sensor.

22. (previously presented): The wheel rotation detecting device as set forth in claim 1, wherein said second sensor includes an acceleration sensor.

23. (previously presented): The wheel rotation detecting device as set forth in claim 1, wherein said second sensor includes an vibration sensor, and wherein said vibration sensor is disposed in series with said first sensor in an axial direction of said holder and nearer to a base end side of said holder than said first sensor in the axial direction of said holder.

24. (previously presented): The wheel rotation detecting device as set forth in claim 1, wherein said second sensor includes an acceleration sensor, and wherein said acceleration sensor is disposed in series with said first sensor in an axial direction of said holder and nearer to a base end side of said holder than said first sensor in the axial direction of said holder.

25-28. (canceled).

29. (previously presented): A wheel rotation detecting device, comprising:
a rolling bearing unit including:
a stationary ring supported on a suspension and being unrotatable in use;
a rotary ring supporting a wheel thereon and being rotatable with said wheel; and
a plurality of rolling elements respectively rollably interposed between a stationary side raceway formed in a peripheral surface of said stationary ring and a rotary side raceway formed in a peripheral surface of said rotary ring;
an encoder supported on said rotary ring or on a part mounted on said rotary ring and being rotatable with said rotary ring;
a first sensor supported on said stationary ring or a part mounted on said stationary ring in such a manner as to be opposed to said encoder, for detecting the rotation of said rotary ring; and
at least one second sensor disposed within a holder holding said first sensor, for detecting the condition of said rolling bearing unit,

wherein said second sensor includes a vibration sensor for detecting the vibration of said rolling bearing unit,

further wherein said vibration sensor is one that detects vibrations at least in two directions,

wherein said second sensor outputs a signal used to detect when an abnormality is present in said rolling bearing unit or a portion adjoining said rolling bearing unit, and

wherein said wheel rotation detecting device further comprises:

a threshold value setting circuit that sets a threshold value in accordance with the rotation speed of said rotary ring detected by said rotation detecting sensor so as to increase said threshold value as said detected rotation speed increases;

a comparator for comparing said threshold value with the detect signal of said second sensor; and

an abnormality judge circuit for judging the presence or absence of said abnormality in accordance with an output of said comparator.

30. (previously presented): A wheel rotation detecting device, comprising:

a rolling bearing unit including:

a stationary ring supported on a suspension and being unrotatable in use;

a rotary ring supporting a wheel thereon and being rotatable with said wheel; and

a plurality of rolling elements respectively rollably interposed between a stationary side raceway formed in a peripheral surface of said stationary ring and a rotary side raceway formed in a peripheral surface of said rotary ring;

an encoder supported on said rotary ring or on a part mounted on said rotary ring and being rotatable with said rotary ring;

a first sensor supported on said stationary ring or a part mounted on said stationary ring in such a manner as to be opposed to said encoder, for detecting the rotation of said rotary ring; and

at least one second sensor disposed within a holder holding said first sensor, for detecting the condition of said rolling bearing unit,

wherein said second sensor includes an acceleration sensor for detecting acceleration of said rolling bearing unit,

further wherein said acceleration sensor is one that detects accelerations at least in two directions,

wherein said second sensor outputs a signal used to detect when an abnormality is present in said rolling bearing unit or a portion adjoining said rolling bearing unit, and

wherein said wheel rotation detecting device further comprises:

a threshold value setting circuit that sets a threshold value in accordance with the rotation speed of said rotary ring detected by said rotation detecting sensor so as to increase said threshold value as said detected rotation speed increases;

a comparator for comparing said threshold value with the detect signal of said second sensor; and

an abnormality judge circuit for judging the presence or absence of said abnormality in accordance with an output of said comparator.

31. (canceled).

32. (previously presented): The wheel rotation detecting device as set forth in claim 30, wherein said acceleration sensor is one that detects accelerations at least in three directions.

33. (previously presented): A wheel rotation detecting device, comprising:

a rolling bearing unit including:

a stationary ring supported on a suspension and being unrotatable in use;

a rotary ring supporting a wheel thereon and being rotatable with said wheel; and

a plurality of rolling elements respectively rollably interposed between a stationary side raceway formed in a peripheral surface of said stationary ring and a rotary side raceway formed in a peripheral surface of said rotary ring;

an encoder supported on said rotary ring or on a part mounted on said rotary ring and being rotatable with said rotary ring;

a first sensor supported on said stationary ring or a part mounted on said stationary ring in such a manner as to be opposed to said encoder, for detecting the rotation of said rotary ring; and

at least one second sensor disposed within a holder holding said first sensor, for detecting the condition of said rolling bearing unit,

wherein said second sensor includes a vibration sensor for detecting the vibration of said rolling bearing unit;

a period analysis circuit for analyzing the period of the vibration detected by said vibration sensor, and outputting a signal representing said period; and

an abnormality determination circuit for judging the presence or absence of said abnormality in accordance with said signal representing said period and a signal representing the rotation speed of said rotary ring detected by said first sensor.

34. (previously presented): A wheel rotation detecting device, comprising:

a rolling bearing unit including:

a stationary ring supported on a suspension and being unrotatable in use;

a rotary ring supporting a wheel thereon and being rotatable with said wheel; and

a plurality of rolling elements respectively rollably interposed between a stationary side raceway formed in a peripheral surface of said stationary ring and a rotary side raceway formed in a peripheral surface of said rotary ring;

an encoder supported on said rotary ring or on a part mounted on said rotary ring and being rotatable with said rotary ring;

a first sensor supported on said stationary ring or a part mounted on said stationary ring in such a manner as to be opposed to said encoder, for detecting the rotation of said rotary ring; and

at least one second sensor disposed within a holder holding said first sensor, for detecting the condition of said rolling bearing unit,

wherein said second sensor includes a vibration sensor for detecting the vibration of said rolling bearing unit;

an envelope processing circuit for processing a vibration signal output from said second sensor;

a frequency analysis circuit, for receiving the processed vibration signal, for analyzing said processed vibration signal, and for outputting a signal representing a period of the processed vibration signal; and

an abnormality determination circuit for judging the presence or absence of said abnormality in accordance with said signal representing said period and a signal representing the rotation speed of said rotary ring detected by said first sensor.

35. (previously presented): The wheel rotation detecting device as set forth in claim 34, wherein abnormalities in the rolling bearing unit are detected.

36. (previously presented): A wheel rotation detecting device, comprising:
a rolling bearing unit including:
a stationary ring supported on a suspension and being unrotatable in use;
a rotary ring supporting a wheel thereon and being rotatable with said wheel; and
a plurality of rolling elements respectively rollably interposed between a stationary side raceway formed in a peripheral surface of said stationary ring and a rotary side raceway formed in a peripheral surface of said rotary ring;

an encoder supported on said rotary ring or on a part mounted on said rotary ring and being rotatable with said rotary ring;

a first sensor supported on said stationary ring or a part mounted on said stationary ring in such a manner as to be opposed to said encoder, for detecting the rotation of said rotary ring; and

at least one second sensor disposed within a holder holding said first sensor, for detecting the condition of said rolling bearing unit,

wherein said encoder is magnetized along a circumferential direction thereof and said encoder includes S and N poles and non-magnetized areas disposed on a peripheral surface thereof so as to repeat one another at regular intervals along the circumferential direction thereof;

wherein said second sensor outputs a signal used to detect when an abnormality is present in said rolling bearing unit or a portion adjoining said rolling bearing unit, and

a threshold value setting circuit that sets a threshold value in accordance with the rotation speed of said rotary ring detected by said rotation detecting sensor so as to increase said threshold value as said detected rotation speed increases;

a comparator for comparing said threshold value with the detect signal of said second sensor; and

an abnormality judge circuit for judging the presence or absence of said abnormality in accordance with an output of said comparator.

37. (previously presented): A wheel rotation detecting device, comprising:

a rolling bearing unit including:

a stationary ring supported on a suspension and being unrotatable in use;

a rotary ring supporting a wheel thereon and being rotatable with said wheel; and

a plurality of rolling elements respectively rollably interposed between a stationary side raceway formed in a peripheral surface of said stationary ring and a rotary side raceway formed in a peripheral surface of said rotary ring;

an encoder supported on said rotary ring or on a part mounted on said rotary ring and being rotatable with said rotary ring;

a first sensor supported on said stationary ring or a part mounted on said stationary ring in such a manner as to be opposed to said encoder, for detecting the rotation of said rotary ring; and

at least one second sensor disposed within a holder holding said first sensor, for detecting the condition of said rolling bearing unit,

wherein said second sensor outputs a signal used to detect when an abnormality is present in said rolling bearing unit or a portion adjoining said rolling bearing unit, and

wherein said wheel rotation detecting device further comprises:

a threshold value setting circuit that sets a threshold value in accordance with the rotation speed of said rotary ring detected by said rotation detecting sensor so as to increase said threshold value as said detected rotation speed increases;

a comparator for comparing said threshold value with the detect signal of said second sensor; and

an abnormality judge circuit for judging the presence or absence of said abnormality in accordance with an output of said comparator

38. (previously presented): The wheel rotation detecting device as set forth in claim 37, wherein said second sensor includes an acceleration sensor for detecting the vibration of said rolling bearing unit.

39. (previously presented): The wheel rotation detecting device as set forth in claim 37, wherein said wheel rotation detecting device further includes a variable filter passing a signal detected by said acceleration sensor, wherein the variable filter varies a removing frequency or a damping frequency in accordance with the rotation speed.

40. (previously presented): The wheel rotation detecting device as set forth in claim 1, wherein said holder holding said first and second sensors is made of synthetic resin.